

The *NFIRE* Launch: Beating the Sophomore Slump at the Wallops Range

It was an early spring day, 2007, on Virginia's Eastern Shore—a long, flat finger of land separating the Chesapeake Bay from the Atlantic Ocean. The chief of the launch and research range at Wallops Flight Facility (WFF) was reviewing some troubling issues that had cropped up. It was the day before the Range Readiness Review for the *NFIRE* mission, or the Near-Field Infrared Experiment. Launch was just two weeks away.

NFIRE, a Missile Defense Agency (MDA) mission, would be the second orbital launch staged by Wallops in five months. In December 2006, the range had sent the Air Force's *TacSat-2* satellite into space. *NFIRE*, like *TacSat-2*, would be hoisted into orbit on an Air Force *Minotaur I* rocket from Wallops' Pad Zero-B of the Mid-Atlantic Regional Spaceport.

Some had perceived undertaking two such launches in this timeframe as irrationally optimistic, to put it kindly. Not so Jay Pittman, Range and Mission Management Chief, and a man known to speak with contagious enthusiasm about the nimble, rapid-integration capabilities of NASA's only launch facility. To Pittman, staging the two missions close together exemplified the "dynamic, can-do" nature of Wallops.

TacSat-2 had gone off without a hitch, and valuable lessons had been assiduously collected from that winter launch at dawn. Without question, *NFIRE* was benefiting from those lessons. But the new issues that threatened *NFIRE* hadn't been entirely

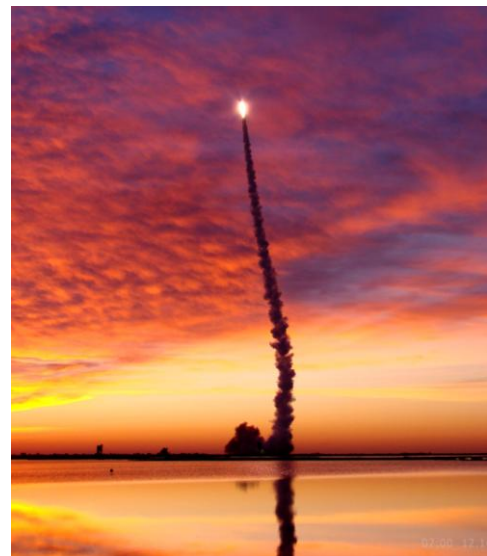


Figure 1 - TacSat-2 Soars into the Sky from the Wallops Range at 7 A.M., December 16, 2006. NASA image

foreseen. Without correction or assurance of the integrity of the problematic systems, a costly destacking (removing the spacecraft from the launch vehicle) and launch delay—or worse—could ensue. The Range Readiness Review would be Pittman's opportunity to assign actions to the project team to address the problems. He would either recommend a delay, or declare that Wallops was ready to launch. As Pittman anticipated the critical meeting, he ran through the issues in his mind.

Wallops: Rich Tradition... and Fast Track to the Future?

Since the first rocket lifted off from the island on the Fourth of July, 1945, Wallops had been the site of some 16,000 launches, mostly suborbital sounding rockets and balloons. In addition, it had served as a testing stage for countless science instruments and flight vehicles. *TacSat-2*, when it launched on December 16, 2006, was the first ground-based orbital launch from Wallops in more than a decade. The turnaround time to get *TacSat-2* into space was less than six months—a fraction of the lifecycle for spaceflight missions. The fast track to the *TacSat-2* launch—and from *TacSat* to *NFIRE*—seemed to signify a shift at Wallops from an under-the-radar research range to a unique national resource for low-cost access to space.



Figure 2 - The Launch Range at Wallops Flight Facility on the Eastern Shore of Virginia. NASA image

The launch had occurred, as Pittman put it in range parlance, at “all balls”—exactly on time and as planned, to the tenth of a second. Success did not mean, however, that there was nothing to improve upon, or that there were no learning opportunities. In fact, by the time the Air Force satellite had been acquired, 90 minutes after launch, by a local telemetry system on the spacecraft's first overflight of Wallops, most of the attention on the island had already turned to an upcoming three-month mission in Alaska and to the next expendable launch vehicle (ELV) orbital mission at Wallops: *NFIRE*.

A Sensitive Satellite

The *NFIRE* satellite, a \$300 million payload, was designed to help detect inter-continental ballistic missiles (ICBMs), and to study the viability of a missile-defense laser communication system. Sensitivity of the satellite to radio-frequency (RF) emissions was a concern from the start. The high power of the

range transmitters, and the even higher-power phased-array systems routinely used at Wallops in Navy operations, could easily damage the sensors and experimental packages on board *NFIRE*.

The *Minotaur* I rocket was a commercial four-stage vehicle, the first two stages of which were taken from the retired *Minuteman* booster fleet. Its upper stages were modern commercial components provided by Orbital Sciences Corporation (OSC). Because the rocket was a derivative of an ICBM, its use required Wallops, along with the Western Range at Vandenberg Air Force Base in California, to be registered under an arms control accord. Namely, Wallops was designated per the U.S.–Russia Strategic Arms Reduction Treaty (START) as a “treaty-designated launch site” for *Minotaurs*.

Mission Support Services

The range was providing a typical array of services to MDA for the *NFIRE* mission. These included:

- Facilities, including technical spaces (clean rooms, integration areas, etc.) and office space for the MDA team
- Launch preparation, including vehicle transportation and integration
- Launch pad operations, including cranes, lifts, transport, and gantry services
- Payload and instrumentation considerations
- Telemetry and data acquisition and archiving
- Control centers, mission communications, and operational control systems
- Surveillance, clearance, interagency, and international coordination for operations
- Coordination of emergency and contingency operations in the event of anomalies
- Safety assurance for both ground and flight segments
- Logistics support for the technical and human resources supporting the mission

Those were typical services Wallops provided for various missions and vehicles, from uninhabited aerial vehicles (UAVs) to *Delta II*-class ELVs and the *Minotaurs*. The Wallops launch manager, or project manager (PM), was responsible for the delivery of all launch range services to the customer (on *NFIRE* as on all missions). The PM was supported by a team staffed and tailored uniquely for the mission.

TacSat-2 Lessons for *NFIRE*

The Wallops assistant PM had served as project manager for *TacSat-2*. The assistant PM, the *NFIRE* PM, and Pittman, the Range and Mission Management Chief, were all committed to applying to *NFIRE* lessons learned from the previous *Minotaur* launch. Some of the inputs from those lessons were:

- Roles and responsibilities had worked well and seemed well allocated. NASA’s responsibility had been to provide for the safety of participants and the public, while the Air

Force customer retained mission assurance roles. A high degree of trust had been established between the teams

- Further, virtually all the same customer team members were returning for the second launch.
- A new range control system--the data quality computer "A" (DQCA), a major upgrade to the core safety function of the range control center--had worked well. DQCA, which consisted of a pair of redundant, identical systems for failsafe purposes, would be used in all future missions. The legacy system would be eliminated.
- The normal range practice of adding a Range Integration Test Manager to coordinate all testing had been executed too late, two months before launch. Because of technical changes, the test manager lacked time to optimally define all test procedures. A great deal of additional effort had been required to complete this work.
- The antiquated intercoms at Wallops were so noisy that some channels planned for use had been abandoned on launch day in favor of backup channels. This left no fallback plan in case of a failure.
- In a related lesson, a controversial decision to change "permanent" intercom channel assignments at Wallops had taken place. This was to allow the Air Force to use the prime "Channel One." However, this had *not* caused the expected confusion among the many range elements that had used that channel exclusively for more than 15 years.
- During one pre-launch test of the vehicle flight termination system (FTS) receivers, a Navy P-3, a patrol aircraft, operating nearby had transmitted signals using the same frequency as the planned FTS command signal.
- NASA's Safety and Mission Success Review (SMSR) was the evaluation tool for assessing the readiness of a spacecraft/payload. In the view of Pittman and according to the Wallops lessons-learned system, the *TacSat-2* launch had demonstrated that there was no better review of range readiness, including safety of the services provided, than the Wallops Range Readiness Review. It had an appraisal process modeled on other ranges and familiar to the Air Force customer.



Figure 3 - NFIRE's fueled upper stage being mated to Lower Vehicle Stack. NASA image

By February 21, 2007, at a pre-ship review about two months before scheduled launch, representatives from OSC, MDA, and WFF, the Wallops Flight Facility, agreed that all elements were ready for shipment to the launch site. Ground support equipment, including specialized containers, trailers, and handling equipment, had been left at Wallops from the *TacSat-2* launch. From a range perspective, even though the value of the *NFIRE* spacecraft was higher than *TacSat-2* by roughly a factor of 10, the complexity of the mission was largely the same. Much of the discussion centered on the notion: “It’s the same launch vehicle and basically the same trajectory, so everything is the same as last time.” In many ways, yes. But...

The Same—But Different

Besides the value of the satellites, several differences between the two missions were immediately obvious. On the vehicle side, the most obvious difference was the presence of hydrazine, a caustic and extremely toxic propellant to be used on the *NFIRE* satellite for in-orbit thrust maneuvers. Further, during the pre-ship review, it was learned that the first- and second-stage boosters for the *NFIRE* mission were the oldest, at more than 40 years, in the Air Force inventory. It had been 10 years since the Wallops team had dealt with hydrazine. But all safety team members had maintained current training and certifications for management and oversight of hydrazine operations.



Figure 4 - Vehicle Stacking on Launch Pad Zero-B, Mid-Atlantic Regional Spaceport, Wallops. NASA image

On the range side, the short time between the two missions left little time for changes. (Although few were thought to be needed). The biggest change was the DQCA as a replacement for its predecessor, the range data system (RDS). During *TacSat-2*, the DQCA had run parallel to the nearly obsolete legacy system that for 20 years had driven virtually all range control center and safety decision tools. DQCA’s error-free operation on *TacSat-2* had been determined to be the final test for acceptance into operational use. The RDS had been disconnected from operational networks.

Finally, the range team had completed an assessment of the spurious noise on the intercom channels. There was not enough money to upgrade the intercom system. However, the Air Force and the PM accepted a re-allocation of channel assignments and backups to the least noisy channels.

The 40-day run-up to launch included: vehicle stage delivery and integration, payload delivery and fueling (with hydrazine), transport to the launch pad, range configuration (local systems as well as Wallops and Air Force downrange systems), and integrated testing of all mission systems.

Too Good to Be True: Problems Surface!

Three weeks prior to launch, and one week before the Range Readiness Review, some problems began to rear their heads. On the eve of the review, three issues in particular were still demanding the attention of the range chief:

Data Quality Computer “A”

The DQCA, the new core of all range and range-safety processing and display functionality, experienced a “hard crash” during a mission simulation. The system functioned nominally after a reboot, but the reboot took more than two minutes—an agonizingly long time during launch operations. Only one of the two systems was required to be functioning during flight, but launch constraints required redundant systems at liftoff. A failure during the final countdown to liftoff would require an expensive, month-long destacking procedure. Loss of both systems during flight would require termination of the flight and loss of the payload.

The problem was traced to a computer board on one of the two DQCA subsystems; it was not present on the other half of the redundant system. DQCA reliability had been established through a months-long testing regimen to establish “mean time between failures.” There would not be enough time to repeat that full test.

Nozzle Oscillation

A violent oscillation had been observed on the documentary video during the “nozzle sweep test.” The test checks the performance of the first-stage systems that thrust and guide the rocket. Such an oscillation could prevent the vehicle from being able to steer itself and from achieving the desired orbit, or any orbit.

After consultation with the range and the Air Force, an independent review team of experts with long U.S. Department of Defense experience with the booster reported that the behavior was “not out of family.” This team concluded the behavior would not occur when the nozzles were actually being fired. In sum, the *Minotaur*’s FTS, or flight termination system, designed to destroy an errant vehicle, could not be affected by the oscillation. Actual data from previous instances of such oscillations, however, could not be obtained for analysis before the launch date.

Signal Interference

During the dress rehearsal for launch, a Navy *P-3* had transmitted RF signals on the frequency used for FTS command uplink. Frequency monitoring detected the signal long before it was a potential problem, but the rehearsal had to be repeated as a result. After a review of NASA’s request to the Navy for RF avoidance of that frequency, the Navy assured the range that no such incidents would occur on launch day.

“Where Do I Worry?” Your Turn...

It is Range Readiness Review day, two weeks before the scheduled launch of *NFIRE*. You are the range chief. At the review are members of your engineering team, and representatives from safety, Goddard’s Safety and Mission Assurance Directorate, Goddard’s management, the MDA’s safety organization, and the customer, the Air Force. The biggest question before you now, as it is before every launch, is: “Where do I worry, and how much?” Some of the problems are not the direct responsibility of the range; nonetheless, they all have a potential impact on launch.

A quick rundown for the review:

- *DQCA*: This is clearly your problem—but what should you do about it? The PM suggests reconnecting the legacy RDS system and reverting back to the configuration used for *TacSat-2*. This would effectively provide “redundant redundant” systems. However, it also would provide increased cost, complexity, and system-testing risk. The Air Force is uncomfortable with additional launch constraints, but has no recommendations.
- *Nozzle problem*: While the nozzle is a vehicle system that does not seem to affect the range’s role, a failure would be catastrophic for the project. Moreover, it would be hard to avoid the perception that it wasn’t a “NASA–Wallops failure.” Besides, if something poses a risk to the entire mission, it becomes the range’s problem. The nozzle anomaly does not appear related to the age of the booster. However, you do not have much data on it, and can’t get data without a substantial launch delay. The Air Force recommends closing the issue without action.
- *Navy P-3*: You reassure yourself that there are many reasons to be less concerned with this issue: The *P-3* signal cannot cause the launch vehicle to self-destruct; the potential for interference is limited to the local launch area, which is monitored for air traffic and frequency interference; the downrange areas are outside of *P-3* routes; and the Navy has promised not to have any *P-3*s working on launch day. Still, the risk that the FTS receivers on the launch vehicle might be overwhelmed by aircraft transmissions preys on your mind.

In addition, there is a fourth concern that hasn’t gone away:

- The communications channels have remained noisy, and there have been quite a few changes to long-standing practice. Dress rehearsals have been relatively clean in terms of team communication, but some operations’ team members have complained about the changes and about “the range making up its mind.” Reports of sporadic noise on some of the 30 launch channels still occur regularly during practice counts; however, alternate channels are assigned to limit impact.

Discussion

Time to decide: Which issues are most important? Where do you need to worry most? How will you address the problems that absolutely must be resolved in order to launch *NFIRE* successfully?

Discuss your rationale for declaring yourself “Ready” or “Not Ready” for launch at the Range Readiness Review. Describe any actions you would assign to your team.